



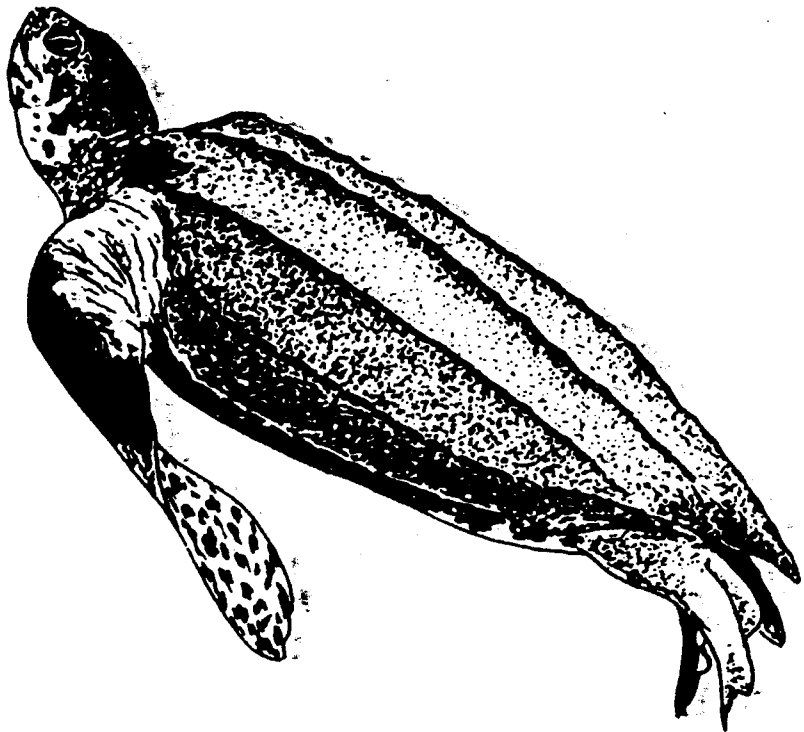
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APPLICATION OF SONIC TELEMETRY FOR IDENTIFICATION OF CRITICAL HABITAT OF SEA TURTLES

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INTRODUCTION

Recent reviews cite the need for information on spatial and temporal distribution and the use of shallow waters by juveniles and subadult sea turtles as a critical research priority (Magnuson et al. 1990; Thompson et al. 1990; Species' recovery plans). The goal is to assess the role of various habitats in supporting sea turtles, particularly juveniles and subadults, and possible conflicts with anthropogenic practices. Protection of juvenile and subadult life stages is critical for ensuring the survival of loggerhead sea turtles in the South Atlantic Bight (Crouse et al. 1987), and likely for the recovery of other sea turtle species (Magnuson et al. 1990).

NMFS research showed that North Carolina's inshore waters are important to various life stages of three sea turtle species, and delineated general seasonal and distribution patterns in the Pamlico-Albemarle Estuarine Complex (Epperly et al. 1995a, 1995b). Densities of sea turtles in Core Sound are especially high (Ibid.). How these inshore waters are used by the inhabiting sea turtle species is not known. Habitats in Core Sound are diverse and within a short distance include shallow muddy tidal creeks and bays along the western shore, channels in the open sound, and a broad shallow shelf to the east which contains large expanses of submerged, rooted vascular plants (SRV, e.g. seagrass). SRV habitats in Core Sound are being mapped; in 1988 they accounted for 6637 ha of the subtidal land in Core and Back Sounds, or about 35% of the subtidal area (Ferguson et al. 1993).

The concentration and overlapping distribution of immature Kemp's ridley, green, and loggerhead sea turtles in the Pamlico-Albemarle Estuarine Complex offers a unique opportunity to examine all three species simultaneously and compare their inshore habitat requirements. The purpose of this study was to determine whether turtles' preference/avoidance of habitats could be determined from positional information obtained while the turtle was at the surface.

MATERIALS AND METHODS

Three immature loggerhead sea turtles (*Caretta caretta*) were obtained from local fishermen. A telemetry package was attached to each animal by tethering it with 120 lb test nylon coated stainless steel wire to the postcentral scutes. The tether was approximately one-half the straight line carapace length (SCL) of the turtle, and contained a short (<3 cm) break-away link of 25 lb test monofilament line and stainless steel ball bearing swivels at each connection site. Each telemetry package consisted of a Telonics MOD-50 radio transmitter with marine helical antenna, inserted into the end of a torpedo buoy for flotation, and a Sonotronics XTAL-87L sonic transmitter suspended below the float. The animals were released in the vicinity of their capture site. We used a Telonics TR-2 receiver and Sonotronics USR-91 narrowband receivers with directional hydrophones to monitor the animals. The radio receiver used an AVM Yagi antenna with a null-peak system.

The animals were tracked simultaneously from two small boats, anchored with a 3-point system to stabilize the boats' movements. Each position of the boats was determined by averaging 40+ differentially corrected Global Position System (GPS) readings collected at 15 sec intervals. Synchronized sonic bearings to the turtle were recorded

every 5 min. Additional bearings were taken every time the animal surfaced (determined by the reappearance of a radio signal). Personnel on the boats were in radio contact and compared each bearing to ensure bearing angle between the boats and the turtle was between 45° and 135°; if the turtle moved outside of this range, one or both boats relocated.

System bias for each set of equipment and for both observers was determined using the methods of Collazo and Epperly (1995) and Braun et al. (in review). Individual bearings to the turtle were corrected for system bias. The location of an animal was determined by triangulation using the synchronized corrected bearing pair and the known locations of the boats. Circular error polygons (50% and 95%) were constructed about these points. This error polygon is described by the radius of a circle which encompassed 50% or 95% of the location errors (distance between estimated location and known location) in system test data sets. Because location error is largely a function of geometric mean distance (D_g) between the boats and the turtle (Collazo and Epperly 1995; Braun et al. in review), the radius of the error polygon can be predicted by a linear model (e.g. 50% error = $18.87 + 0.18D_g$; Braun et al. in review). The turtle positions and their error polygons were related to depth and to the presence of SRV habitat using ARC/INFO GIS version 7.0. SRV habitat data were from 1988 (Ferguson et al. 1993); depth data were from 1995. The results from one of the turtles follow:

RESULTS

A 56.0 cm SCL, 27.4 kg loggerhead was tagged and released on 2 Sep. 1994. It was monitored between the hours of 0945 and 1545 EST on 7-9 Sep. in Back Sound. During 17 h of monitoring, 206 positions were obtained at D_g 's of 66-1,095 m (median=314 m). The distances between subsurface positions, perceived as movement by the turtle along the bottom during a 5 min observation interval, significantly deviated from a normal distribution: the median distance moved was 52 m (25% quartile=35 m, 75% quartile=91 m). The distribution of location errors associated with the subsurface positions also was not normal: the median distance of 50% location errors was 78 m (25% quartile=63 m, 75% quartile=117 m) and the median distance of 95% errors was 178 m (25% quartile=133 m, 75% quartile=299 m).

Study area

Submerged rooted vegetation accounted for 27% of the available habitat in the 287 ha study area, defined as the area bounded by the extremes of the 206 turtle positions. Depths in the area generally were less than 2 m, but a narrow channel with depths up to 7 m occurred to the north.

Relation between turtle positions and available habitat

(Based on underwater positions of the turtle)

The loggerhead turtle never was detected in SRV habitat on 7 or 9 Sep. This avoidance (0% occupation) was significantly less than would be predicted based on a random distribution model (χ^2 test, $p < 0.05$). The turtle occupied some SRV habitat on 8 Sep. (8% of the positions); the distribution of positions on this day was consistent with the hypothesis that there was neither preference nor avoidance of vegetated and non-vegetated habitats (χ^2 test, $p > 0.05$).

The loggerhead turtle did not randomly associate with depths on 7 or 9 Sep. Instead, it preferred depths greater than widely available, but avoided the depths of the channel (χ^2 test, $p < 0.05$). The turtle never was detected in the channel despite occupying the southern rim of the channel for most of 7 Sep. The turtle's distribution on 8 Sep. was consistent with the hypothesis of no preference or avoidance of depth (χ^2 test, $p > 0.05$).

Comparison between surface and bottom positions

Sixty-nine positions were obtained during surfacing events. Each surface position was compared to the bottom position acquired immediately before and/or immediately after the surfacing event to determine if classification of habitat (vegetated vs. non-vegetated) differed. The turtle did not appear to leave the area of its berthing

habitat or to alter its course to surface. The classification of the surface position differed from adjacent bottom positions in only three of 100 comparisons. In each of the three cases, the turtle had moved some distance before surfacing, but was still well within the 50% error polygon about an adjacent underwater position.

CONCLUSION

Past studies have shown sonic telemetry to be a feasible tool to evaluate habitat use studies in Core Sound (Collazo and Epperly 1995; Braun et al. in review). Use of specialized tags, such as LORAN tags, which function only when the animal is on the surface, have been of uncertain application for sea turtle habitat studies because it was not known how far a turtle moved laterally from its submerged "berthing" location before surfacing. If the movement is significant, then sonic telemetry, used when the animal is underwater, is the only means to conduct habitat utilization studies. If the lateral movement is insignificant, then LORAN or UHF tags could be used to monitor and classify the habitat at a turtle's location. These mid-range tags afford a more cost effective method to collect positional data on a large number of turtles for habitat utilization studies because the data can be acquired remotely.

In the relatively shallow waters of Back Sound, lateral movement between underwater "berthing" positions and surfacing positions of a loggerhead turtle was insignificant. Furthermore, the turtle did not alter its behavior to surface. We assume the results from this single turtle are applicable to other turtles in most of North Carolina inshore waters, because these waters are relatively shallow and without deep channels, and a turtle has to traverse but a short water column to surface. We conclude that technologies which identify the position of a sea turtle when it is on the surface can be used to conduct habitat utilization studies when the turtle is in relatively shallow inshore waters, provided accuracy and precision are within acceptable limits. During 1995, we will evaluate the accuracy and precision of positional data obtained from LORAN tags.

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THE BREEDING MALES OF BOUNTIFUL, RAINE AND HERON ISLANDS: WHAT FEMALE INHERITED MARKERS CAN TELL US ABOUT MALE REPRODUCTIVE BEHAVIOUR.

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Among the mysteries of marine turtle biology are the largely unknown journeys of the male turtles. Research has indicated that Chelonia mydas males display fidelity to both breeding and feeding grounds and that their breeding migrations may be more frequent than females (Balazs 1980, Limpus 1993). However, the question remained as to whether male fidelity was to their natal regions as has been reported for several female nesting populations (Bowen et al. 199, Meylan et al. 1990, Broderick et al. 1994, Norman et al. 1994). Genetic studies using anonymous nuclear loci (Karl et al. 1992) have suggested that moderate levels of male-mediated gene flow occur among regional populations on a global scale and the authors speculated that matings might occur on overlapping feeding grounds, along migration corridors or at non-natal rookeries.

To address questions about male behaviour and male-mediated gene flow, we integrated a comparative genetic approach with an extensive tagging effort of males at both feeding and breeding grounds in Queensland (Limpus 1993). Initially we analysed green turtle populations throughout Australia for allelic diversity at 4 highly variable microsatellite loci found within the nuclear DNA (FitzSimmons et al. 1994). We found significant genetic divergence in nearly all pairwise comparisons between the four regions tested: Southern Great Barrier Reef (SGBR), Northern Great Barrier Reef (NGBR), Gulf of Carpentaria (GOC) and Western Australia, with the single exception of no significant divergence between the NGBR and SGBR populations. These results indicated that males may exhibit similar regional fidelity to breeding regions as demonstrated for females (Norman et al. 1994), but that some male-mediated gene flow was likely occurring between certain regions, namely NGBR and SGBR.

We looked more closely at natal fidelity by comparing the frequencies of mitochondrial DNA (mtDNA) haplotypes of breeding males to those of nesting females (Norman et al. 1994) in three locations: Heron Island (SGBR), Raine Island (NGBR), and Bountiful Island (GOC). Our results indicate that the haplotype frequencies in each region were the same for both males and females. Thus, males are mostly breeding in their natal regions, as was previously found for females (Norman et al. 1994).

In conclusion, male-mediated gene flow between regions is probably not as prevalent as previously suggested (Karl et al. 1992), though it likely occurs between some regions, such as observed between the NGBR and SGBR. The extent to which male-mediated gene flow occurs is unknown